Automatic Filament Warm-Up Controller

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As part of the unattended operations objective of the DSN deep space stations, this filament controller serves as a step between manual operation of the station and complete computer control. Formerly, the operator was required to devote five to fifteen minutes of his time just to properly warm up the filaments on the klystrons of the high power transmitters. The filament controller reduces the operator's duty to a one-step command and is future-compatible with various forms of computer control.

I. Motivation

As part of the unattended operations objective of the DSN deep space stations, this filament controller serves as a step between manual operations of the station and complete computer control. Formerly, the operator was required to devote five to fifteen minutes of his time just to properly warm up the filaments on the klystrons of the high power transmitters. The filament controller reduces the operator's duty to a one-step command and is future-compatible with various forms of computer control.

II. Design Requirements

The controller was designed to incorporate the following characteristics:

(1) Automatic warm-up of filament upon command

(2) Noise immunity to crowbar firings on beam supply

(3) Fail-safe power failure design

(4) Protection from operator induced errors

(5) Beam interlocks to prevent maltreatment of tube

(6) Filament current and voltage monitoring outputs

(7) Compatibility with computer control

(8) Digital switches for setting klystron operating filament voltage and current

III. System Configuration

Klystron application circuitry is such that the filament floats at full beam potential. This can be up to 70 kV, so an isolation transformer with filament voltage and current sense windings is used to supply filament power. These sense voltages are rectified with peak detectors using operational amplifier and appropriately filtered to remove transients. The power to the isolation transformer is supplied by a motor-controlled Variac, which is controlled, in turn, by the circuit board (Figs. 1 and 2).

When the user issues a warm-up command (raise) at the Local Control Console (LCC), the circuit applies power to the Variac via a solid state relay, and turns the motor on in the "up" direction. The motor continues to run until the maximum programmed current or the operating voltage limit is reached. When the filament is cold and the resistance low, it will always current limit first, and will pulse the motor every few seconds, maintaining the current at the limit as the filament warms up. When the filament reaches 70 percent of its operating voltage, a 20-minute timer is started. This timer, with other conditions, generates the filament ready signal, which enables the beam voltage interlock (Fig. 3).

When the filament is hot and current limiting no longer occurs, the filament voltage is regulated to within ±0.1 volt. A filament shutdown can now be initiated by three events: (1) a down command from the operator, (2) a failure of the cooling (filament flow), or (3) a power failure for more than a few seconds.

An operator shutdown command would consist of pressing "lower" switch (Fig. 1), which changes the circuit mode from "up" to "halt" to "down." A cooling failure forces a "down" mode, but only after a one-minute time delay. A power failure longer than five seconds causes the circuit to be reset, removing filament power and mechanically lowering the Variac when power returns. The Variac must be lowered to its limit before it can again be raised.

Another feature allowing either manual or external computer control is the override function (Fig. 3). When enabled, it suppresses the voltage regulating action of the circuit, but not the safety features. When override is enabled, the raise and lower buttons at the LCC control the motor connected to the Variac, still subject to the current and voltage limit set by switches in the filament supply chassis. This allows an operator or computer to directly control the filament power.

A complete filament chassis has now been built and will be tested in an operational transmitter at DSS 13.

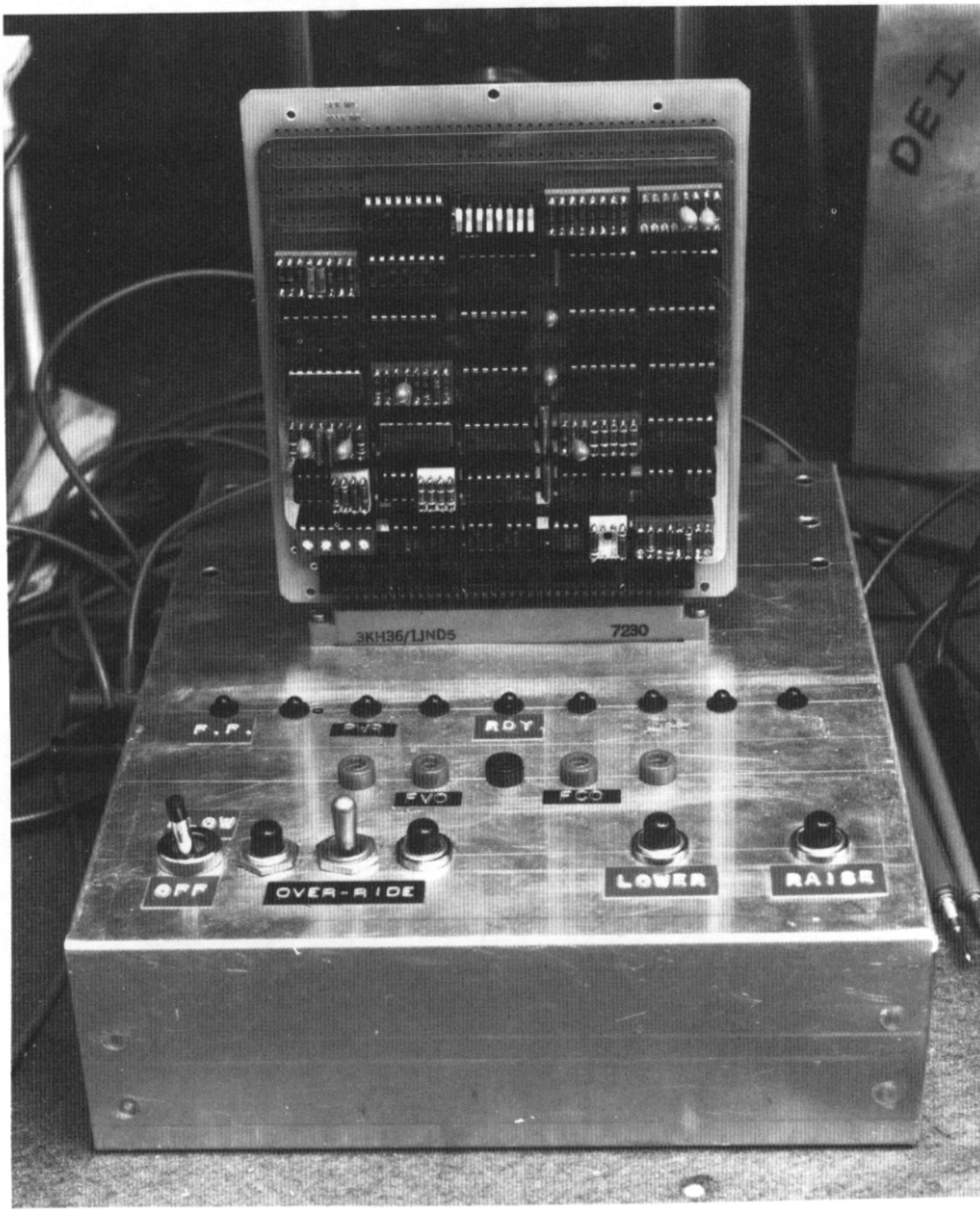

Fig. 1. Prototype circuit board to bench test the automatic circuit

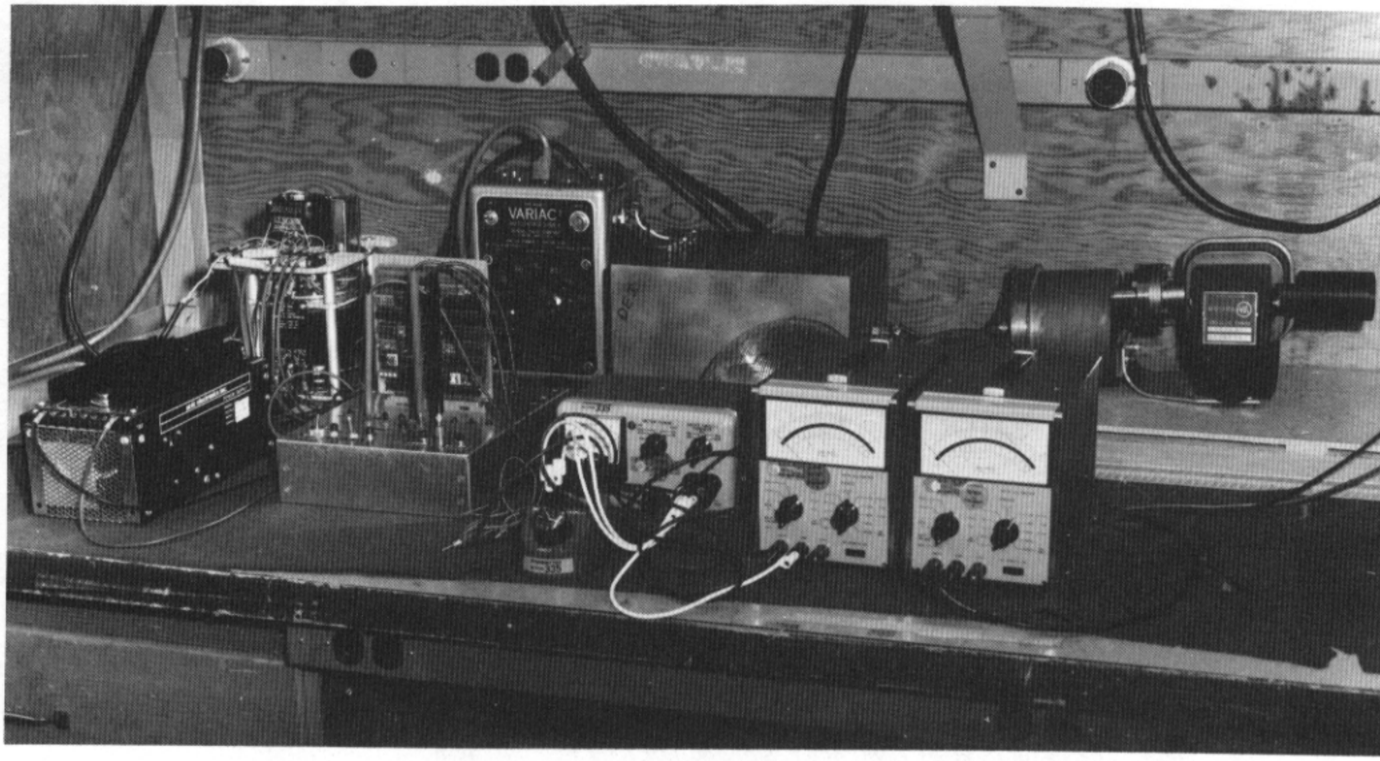

Fig. 2. Complete bench test setup using an actual klystron filament

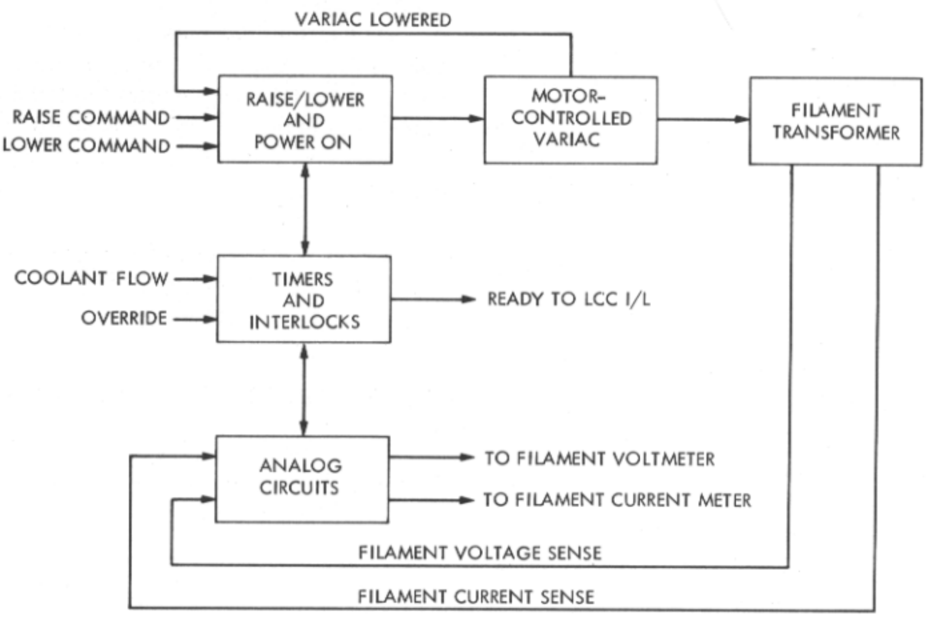

Fig. 3. Block diagram of the controller